ISSN 1392-3196
Zemdirbyste-Agriculture, vol. 95, No. 3 (2008), p. 171–179
UDK 635.25:632.952

THE EFFECT OF FUNGICIDES ON THE DEVELOPMENT OF DOWNY MILDEW OF ONIONS

Elena SURVILIENĖ, Alma VALIUŠKAITĖ, Laimutis RAUDONIS

Lithuanian Institute of Horticulture
Babtai, Kaunas distr., Lithuania
E-mail: e.surviliene@lsdi.lt

Abstract

Experiments were conducted during the period of 2004–2007 and were designed to study the impact of the fungicides Acrobat Plus (dimetomorf 90 g kg^{-1}, mancoceb 600 g kg^{-1}), Amistar 250 SC (azoxystrobin 250 g l^{-1}), Infinito SC 687.5 (fluopicolide 62.5 g l^{-1}, propamocarb HCL 625 g l^{-1}), Penncozeb 75 DG (mancoceb 750 g kg^{-1}) and Signum 33 WG (pyraclostrobin 67 g kg^{-1}, boscalid 267 g kg^{-1}) on the epidemic progress of downy mildew on the onion cv. ‛Stuttgarter Riesen’. The first disease symptoms appeared in the beginning of July. Three fungicide spray applications significantly suppressed the disease incidence; the biological efficacy of the fungicides averaged 74.38–89.36% and increased the marketable onion yield by 4.3–26.3%.

Key words: *Allium cepa*, *Peronospora destructor*, downy mildew, fungicide, yield.

Introduction

Downy mildew of onion caused by *Peronospora destructor* [Berk.] Casp. is an economically important disease and occurs in most onion *Allium cepa* L. producing regions throughout the world, causing losses in both yield and quality /Lorbeer, Andaloro, 1984; Schwartz, Mohan, 1995; USDA, Crop Profile for Onion, 2003/. Actual yield losses in bulb onions of 60 to 75% have been recorded /Develash, Sugha, 1997 b/. These losses mainly result from severe infections in bulb onion crops causing early defoliation, reduced bulb sizes, and poor storage quality of bulbs /Lorbeer, Andaloro, 1984; Gilles et al., 2004; Gianessi, Reigner, 2005/. In salad onions, yield losses can be as high as 100%, with whole crops being discarded as downy mildew symptoms make them unmarketable. Losses to seed production are frequently caused by the collapse of infected seed stalks and poor germination of seeds collected from infected stalks /Schwartz, Mohan, 1995/.

The disease can cause serious losses within a short period of time during cool and humid weather conditions /Hoffmann et al., 1996/. Oval or cylindrical areas of varying sizes develop on infected leaves. These areas are pale greenish-yellow to brown in colour (Figure). Symptoms often appear first on older leaves. If weather conditions are moist and temperatures are low, masses of grey to violet fungal spores envelop infected leaves, which become girdled, collapse, and die. The dead leaf tissue is rapidly colonized by purple blotch, which is dark in colour and obscures downy mildew.

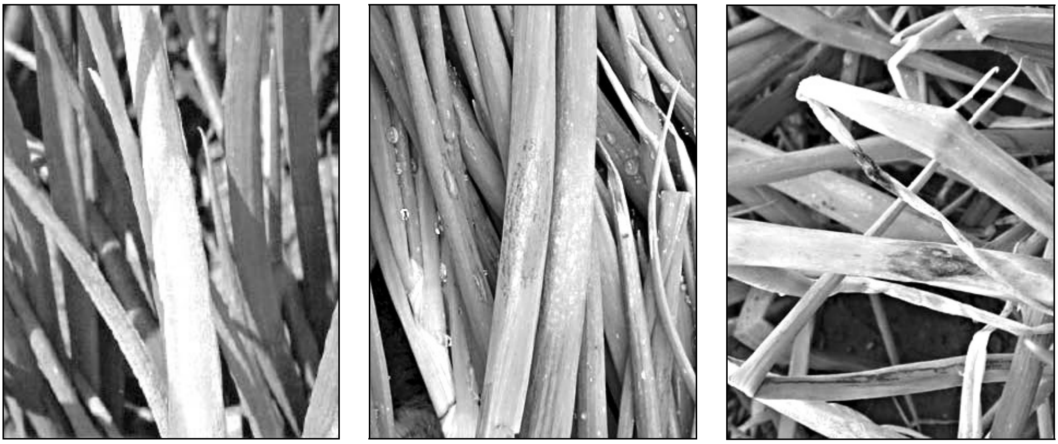

Figure. The symptoms of downy mildew on onion leaves (photo by E. Survilienė)

Downy mildew management includes the means such as planting timing, resistant cultivars, soil drainage, seed or bulb health stock, wind block /Schwartz, Mohan, 1995; Hoffmann et al., 1996; Develash, Sugha, 1997 a; Krauthausen et al., 2001/. The influence of variable fertiliser levels was also significant on downy mildew /Ahmad, Khan, 2001; Goncalves et al., 2004/.

The principal means of controlling the downy mildew is by applying fungicides and the efficiency of protection means depends on their application time and disease development level. The current IPM recommendation is to apply fungicides at the first sign of downy mildew /Hoffmann et al., 1996; Develash, Sugha, 1997 a; Wright et al., 2002; UC IPM Pest Management..., 2002; Gianessi, Reigner, 2005/. Generally, preventive fungicide sprays are scheduled 7–10 days apart to control downy mildew and to ensure good yields and high crop quality /Palti, 1989; De Visser, 1998/. On the other hand, fungicide applications undertaken during unfavourable weather conditions for infection and disease spread are economically and ecologically superfluous.

In Lithuania, especially in the regions of extensive onion production, the incidence and the severity of downy mildew have increased in recent years. Therefore effective plant protection means are in great demand. Up to 2006 only mancozeb was registered for use for the control of downy mildew in onion in Lithuania and only since 2007 other active ingredients, such as dimetomorf, azoxystrobin, fluopicolide, propamocarb HCL pyraclostrobin and boscalid have been scheduled to *Allium* L. plant disease management program /Sodo ir daržo..., 2007/.

The aims of the investigation were to establish the incidence of *Peronospora destructor* on onions and to evaluate the influence of fungicides with the different active ingredients on the prevalence of downy mildew.

Materials and Methods

The trials were carried out at the Lithuanian Institute of Horticulture (LIH), during 2004–2007 to evaluate the effect of fungicide sprays on the management of downy mildew (*Peronospora destructor*) of onion. The trial field was a marginally rolling plain with microrelief. The soil of the experimental site is *Epicalcari-Epihypogleyic Cambisol*, CMg-p-w-cap; with a texture of light clay loam and medium clay loam. The arable layer was weakly alkaline (pH 7.3–7.6), medium humus-rich (2.65–3.36%). In all experimental years, carrots were a preceding crop for onions. In spring, before planting complex fertilisers Cropcare 10–10–20 (600 kg ha^{-1}) were spread. The sets of the onion cv. 'Stuttgarter Riesen' were planted in the beginning of May on 8.0 m long and 1.0 m wide beds by four lines. The trials were arranged in the plots replicated four times. Onions were cultivated according to the technology of onion vegetable growing accepted at LIH.

The trial design involved the following fungicides: Acrobat Plus (active ingredients dimetomorf 90 g kg^{-1}, mancoceb 600 g kg^{-1}) at a rate of 2.5 kg ha^{-1}, Amistar 250 SC (azoxystrobin 250 g l^{-1}) at a rate of 0.8 l ha^{-1}, Infinito SC 687.5 (fluopicolide 62.5 g l^{-1}, propamocarb HCL 625 g l^{-1}) at a rate of 1.6 l ha^{-1}, Penncozeb 75 DG (mancoceb 750 g kg^{-1}) at a rate of 2.0 kg ha^{-1} and Signum 33 WG (pyraclostrobin 67 g kg^{-1}, boscalid 267 g kg^{-1}) at a rate of 1.0 l ha^{-1}. The fungicide efficacy testing was carried out observing the requirements of Good Experimental Practice. The fungicides were applied at the stage of development of harvestable vegetative plant parts (BBCH 20–44) when the first symptoms of downy mildew had appeared. Onions were sprayed for three times every 7–10 days; the last spray was conducted not later than 21 days before harvesting. The surfactant Vegeol (refined rape oil) at a rate of 0.5 l ha^{-1} was added to the spray solution (volume of water – 700 l ha^{-1}).

Disease assessments were made on 10 plants from 3 places per replication immediately before and after 7–14 days of fungicide application. Diseases incidence, severity and biological efficacy of the fungicides were determined according to the generally accepted experimental methods /Žemės ūkio augalų kenkėjai…, 2002/. By the end of August and beginning of September the crop was mature. Statistical processing of the data was carried out by the analysis of variance method according to Duncan's test (P = 0.05).

Results and Discussion

In all experimental years the pressure of downy mildew was severe. Meteorological conditions for onion growing, ripening and appearance of diseases during vegetation in 2004–2007 were diverse (Table 1). The summer of 2006 was hot and dry, which was contrary to the downy mildew infection processes, therefore, the results of this year are not discussed.

Meteorological conditions of 2004 summer were variable – rather cool in the first half of the season and warmer in the second half. June was much more humid than unusual. There was by 20 mm less precipitation in July, but it was very humid in August – precipitation exceeded the monthly rate by 1.6 times. The air temperature was very similar to the multiannual average. In general, the weather was favourable for onion growth, and there was enough precipitation for the infection process. The first symptoms of downy mildew (*Peronospora destructor*) in onion were observed on July 12.

In June 2005 there was more precipitation than usual; the air temperature was a little lower than the multiannual. Under such weather conditions the incidence of downy mildew was recorded on July 4. Later in July it was warm, but dry; the air temperature was higher than the multiannual average and there was almost no precipitation. As a result, the infection process was low. In August it was much more humid, especially in the beginning of the month. Such weather conditions inhibited onion ripening.

Table 1. The mean air temperature and amount of precipitation during the onion growing season

Babtai, 2004–2007

Year	Mean air temperature °C			Amount of precipitation mm		
	June	July	August	June	July	August
2004	13.7	16.1	16.7	77.4	50.4	123.6
2005	14.8	19.4	14.7	66.6	3.8	109.4
2006	16.3	19.3	17.5	1.2	27.6	52.4
2007	15.1	15.2	16.6	72.2	173.6	42.8
Multiannual rate	16.5	17.7	16.4	51.0	71.0	73.5

The first symptoms of downy mildew in onion in 2007 were observed on July 2. The wet weather conditions in June and later unusual excess of rainfall in July influenced the prevalence of downy mildew in onion.

The first sprayings with the foliar fungicides were made immediately after the appearance of the disease symptoms. Before spraying, the incidence of the disease was on average 5.0–10.0%, severity – 0.2–1.21% (Table 2).

Table 2. The level of downy mildew infection in the onion cv. ʻStuttgarten Riesen' before the fungicide application

Babtai, 2004–2007

Treatment	Rate ha^{-1}	Downy mildew					
		Incidence %			Severity %		
		2004	2005	2007	2004	2005	2007
Control (not sprayed)	–	7.5 ab	10.0 b	7.5 ab	0.36 a	1,15 b	0.45 a
Acrobat Plus	2.5 kg	5.0 a	7.5 ab	5.0 ab	0.4 a	0.41 a	0.2 ab
Amistar 250 SC	0.8 l	10.0 ab	5.0 ab	7.5 ab	1.21 b	0.19 ab	0.33 ab
Infinito 687.5 SC	1.6 l	–	5.0 ab	5.0 ab	–	0.35 a	0.19 ab
Penncozeb 75 DG	2.0 kg	10.0 b	7.5 ab	7.5 ab	1.17 b	0.4 ab	0.41 ab
Signum 33 WG	1.0 l	7.5 a	10.0 ab	10.0 b	0,64 a	0.6 ab	1,17 b

Note: Means in columns followed by the same letter are not significantly different (P=0.05) Duncan's multiple range test.

Successive sprayings with fungicides were carried out on July 21 and 30, 2004, on July 15 and 27, 2005 and on July 9 and 17, 2007.

Table 3. The effect of foliar fungicide treatments on downy mildew in the onion cv. 'Stuttgarten Riesen'

Babtai, 2004–2007

Treatment	Downy mildew					
	Incidence %			Severity %		
	2004					
	July 21	July 30	August 9	July 21	July 30	August 9
Control (not sprayed)	20.0 c	45.0 c	60.0 c	12.34 c	22.04 c	52.27 d
Acrobat Plus 2.5 kg ha^{-1}	7.5 a	10.0 a	17.5 a	2.08 b	5.94 ab	7.53 b
Amistar 250 SC 0.8 l ha^{-1}	12.5 b	15.0 ab	20.0 ab	2.0 b	2.73 a	5.6 ab
Penncozeb 75 DG 2.0 kg ha^{-1}	15.0 c	25.0 b	30.0 b	2.27 b	7.76 b	14.58 c
Signum 33 WG 1.0 l ha^{-1}	10.0 ab	12.5 a	15.0 a	1.14 a	2.13 a	3.58 a
	2005					
	July 15	July 27	August 8	July 15	July 27	August 8
Control (not sprayed)	45.0 c	75.0 c	95.0 d	12.04 c	26.91 c	61.73 c
Acrobat Plus 2.5 kg ha^{-1}	7.5 a	20.0 b	30.0 b	3.5 a	8.62 b	15.0 b
Amistar 250 SC 0.8 l ha^{-1}	5.0 a	10.0 a	20.0 b	4.12 ab	7.5 b	12.5 ab
Infinito 687.5 SC 1.6 l ha^{-1}	5.0 a	15.0 ab	22.5 b	1.56 a	5.11 ab	9.38 a
Penncozeb 75 DG 2.0 kg ha^{-1}	12.5 b	25.0 b	32.5 bc	5.42 b	8.91 b	15.49 b
Signum 33 WG 1.0 l ha^{-1}	2.5 a	7.5 a	12.5 a	2.13 a	3.5 a	7.5 a
	2007					
	July 9	July 17	August 4	July 9	July 17	August 4
Control (not sprayed)	30.0 c	50.0 c	80.0 d	13.25 c	19.84 c	32.52 c
Acrobat Plus 2.5 kg ha^{-1}	7.5 a	10.0 a	20.0 ab	0.54 a	2.63 b	6.9 b
Amistar 250 SC 0.8 l ha^{-1}	7.5 a	12.5 a	17.5 a	0.51 a	1.54 a	5.32 a
Infinito 687.5 SC 1.6 l ha^{-1}	5.0 a	7.5 a	17.5 a	0.3 a	1.38 a	5.11 a
Penncozeb 75 DG 2.0 kg ha^{-1}	10.0 ab	20.0 b	32.5 bc	1.3 b	2.9 b	7.5 b
Signum 33 WG 1.0 l ha^{-1}	5.0 a	7.5 a	15.5 a	0.4 a	1.49 a	4.43 a

Note: Means in columns followed by the same letter are not significantly different ($P = 0.05$) Duncan's multiple range test.

It should be noted that during the three experimental years the results of onion leaves analyses showed that the development of disease symptoms was lower on the leaves of chemically protected plants than on the leaves of the control treatment plants (Table 3). During the whole experimental period the level of infection in not sprayed onions increased by on average 9.39 times – the disease incidence increased by 73.0% and the disease severity by 48.19%.

Three applications with the foliar fungicide tested allowed us to maintain the infection level of downy mildew rather low. In the fungicide treatments the disease incidence ranged between 12.5–32.5% and severity – 3.58–15.49%. The lowest disease level was established in the treatment applied with Amistar 250 SC at a rate of 0.8 l ha^{-1}, Infinito 687.5 SC at a rate of 1.6 l ha^{-1} and Signum 33 WG at a rate of 1.0 l ha^{-1}, however, no significant differences were established.

Our experimental findings suggest that all fungicides applied at the stage of development of harvestable vegetative onion parts (BBCH 20–44) significantly suppressed the epidemic process of downy mildew. The mean biological efficacy of the fungicides ranged from 74.38% to 89.36% and it corresponded to fair, good and excellent effect (Table 4). In all the years, good results in reducing infection level of onion downy mildew were exhibited by Signum 33 WG (1.0 l ha^{-1}), Infinito 687.5 SC (1.6 l ha^{-1}), Amistar (0.8 l ha^{-1}) and Acrobat Plus (2.5 kg ha^{-1}) and statistically differed from the efficacy of the fungicide Penncozeb 75 DG (2.0 kg ha^{-1}), except in 2005. The effect of the fungicide Penncozeb 75 DG (2.0 kg ha^{-1}) inhibiting the incidence and severity of downy mildew in onion was from fair to good, biological efficacy ranged between 65.59% and 84.17%. It can be explained by the action of the contact active ingredient mancozeb. Some reports suggest that fungicides containing mancozeb and other active ingredients such as benalaxyl, dimetomorf, metalaxyl are the most effective and result in more than 85% control of onion downy mildew /Develash, Sugha, 1997 a; Hoppe BioEco, 2004/.

Table 4. The efficacy of the fungicides to control downy mildew in the onion cv. ‘Stuttgarten Riesen’

Babtai, 2004–2007

Treatment	Rate ha^{-1}	Biological efficacy %			
		2004	2005	2007	Total mean
Acrobat Plus	2.5 kg	80.59 ab	71.53 a	87.15 d	79.76
Amistar 250 SC	0.8 l	86.9 bcd	72.55 a	90.68 bc	83.38
Infinito 687.5 SC	1.6 l	–	84.29 c	91.69 c	87.99
Penncozeb 75 DG	2.0 kg	72.84 a	65.59 a	84.17 a	74.38
Signum 33 WG	1.0 l	91.42 d	85.72 c	90.95 bc	89.36

Note: Means in columns followed by the same letter are not significantly different (P=0.05) Duncan’s multiple range test.

In our trials the fungicides Signum 33 WG and Amistar 250 SC distinguished themselves by a very good action on the infection process of downy mildew. The biological efficacy of Signum 33 WG and Amistar 250 SC in some years reached 91.42% and 90.68%, respectively. Good efficacy of the strobilurin-containing agents has also been confirmed by the experiments of other authors. The results obtained from the field experiments and after storage of vegetable roots indicate that the protective treatments against the alternaria leaf blight on carrot, powdery mildew on parsley, and septoria leaf spot on celeriac plants during the vegetative period have a significant effect on the health status of these vegetables. The highest efficacy against the above-mentioned diseases was exhibited by azoxystrobin, azoxystrobin + chlorotalonil and pyraclostrobin + boscalid, which proved to be highly effective in preventing infection with storage diseases (over 90%), and had a beneficial effect on the storage life of these vegetable roots in comparison with unprotected objects /Robak, Adamicki, 2007/.

Strobilurin fungicides have become a very valuable tool for managing diseases. They are effective against several different plant pathogenic fungi. For all parameters evaluated, fungicide Signum 33 WG gave comparable or even better results in comparison with the fungicides containing mancozeb, mancozeb + metalaxyl, benalaxyl, triazole, iprodione to control diseases such as *Phytophthora porri* in leek, *Erysiphe heraclei* and *Alternaria dauci* in carrot, *Mycosphaerella* spp., *Albugo candida* and *Alternaria* spp. in Brussels sprouts, *Botrytis cinerea* and *Sclerotinia sclerotiorum* in outdoor lettuce /Callens et al., 2005/.

Infinito 687.5 SC (fluopicolide 62.5 g $^{-1}$, propamocarb HCL 625 g l^{-1}) is a relatively new fungicide, although propamocarb single and mixed with other active ingredients has been used for many years to control *Phytophthora* spp., *Pythium* spp., *Bremia lactuca*, *Peronospora* spp., *Pseudoperonospora cubensis*. The fungicide Tattoo (propamocarb + mancozeb / clorotalonil) was the first commercial product, the next generation is the product Tyfon/Consento/Glory (propamocarb + fenamidone), which today is being launched in many European countries. The next generation has been already developed after Infinito was launched in the United Kingdom in 2006, and more countries are to follow in 2007 and onwards /Juhl, 2006/. There is little evidence on its efficacy in vegetable crops. Fluopicolide is effective at low application rates against a wide range of *Oomycete* (*Phycomycete*) diseases including downy mildews (*Plasmopara* spp., *Pseudoperonospara cubensis*, *Peronospora* spp., *Bremia* spp.), late blight (*Phytophthora infestans*), and some *Pythium* species /Pesticide Fact Sheet, 2007/.

The findings from the 2004–2007 experimental period indicate that the onion crops sprayed with fungicides produced the marketable onion bulb yield by 4.3–26.3% or 0.87–9.34 t ha^{-1} higher, compared with the untreated crops (Table 5). The yield increase was significant.

The highest yield increase was recorded in Infinito 687.5 SC, Signum 33 WG and Amistar 250 SC treatments. The lowest onion yield was obtained from the control treatment. This confirmes the proposition that early defoliation of onion reduced bulb sizes and caused yield losses /Lorbeer, Andaloro, 1984; Develash, Sugha, 1997 b; Gilles et al., 2004; Gianessi, Reigner, 2005/.

To achieve a better control of epidemic process of downy mildew in onion it is important to make prophylactic sprayings or as soon as the first disease symptoms appear, when the disease incidence does not exceed 5.0%. Relative effectiveness of the various fungicide programmes was reflected in increased yield and size of the onions. It was concluded that fungicide programmes should start at about the time of the first sporulation-infection period /Jesperson, Sutton, 1987; Wright et al., 2002/.

Table 5. The influence of the fungicides on the yield of onion cv. 'Stuttgarter Riesen' Babtai, 2004–2007

Treatment	Rate ha^{-1}	Marketable bulb yield					
		$t\ ha^{-1}$			Increase $t\ ha^{-1}$/ %		
		2004	2005	2007	2004	2005	2007
Control (not sprayed)	–	36.54 a	20.31 a	27.26 a	100	100	100
Acrobat Plus'	2.5 kg	43.74 c	23.29 c	32.52 c	7.2 119.7	3.08 114.7	5.26 119.3
Amistar 250 SC'	0.8 l	44.76 c	23.62 c	33.09 c	8.22 122.5	3.31 116.3	5.83 121.4
Infinito 687.5 SC'	1.6 l	–	24.68 c	34.43 d	–	4.37 121.5	7.17 126.3
Penncozeb 75 DG'	2.0 kg	40.97 b	21.18 ab	30.26 b	4.43 112.1	0.87 104.3	3.00 111.0
Signum 33 WG'	1.0 l	45.88 cd	22.85 b	33.78 cd	9.34 125.6	2.54 112.5	6.52 123.9

Note: Means in columns followed by the same letter are not significantly different (P = 0.05) Duncan's multiple range test.

Conclusions

1. Our experimental results indicate that the tested fungicides significantly suppressed the epidemic progress of downy mildew of onion.
2. The mean biological efficacy of the fungicides ranged from 74.38% to 89.36% and it corresponded to fair, good and excellent effect.
3. Due to the use of the fungicides the increase in the onion bulb yield was significant during the experimental years.

Received 2008-06-02
Accepted 2008-07-11

REFERENCES

1. Ahmad S., Khan H. Influence of host management on downy mildew control in onion // Pakistan Journal of Biological Sciences. – 2001, vol. 4 (9), p. 1126–1128

2. Callens D., Sarrazyn R., Evens W. Signum, a new fungicide for control of leaf diseases in outdoor vegetables // Proceedings of the 57th International symposium on crop protection, Gent, Belgium, 10 May 2005. – 2005, vol. 70 (3), p. 199–207

3. Develash R. K., Sugha S. K. Management of downy mildew (*Peronospora destructor*) of onion (*Allium cepa*) // Crop Protection. – 1997 a, vol. 16 (1), p. 63–67

4. Develash R. K., Sugha S. K. Incidence of downy mildew and its impact on yield // Indian Phytopathology. – 1997 b, vol. 50, p. 127–129

5. Gianessi L. P., Reigner N. The value of fungicides in U S crop production. CropLife foundation crop protection research institute. – Washington, DC, 2005. – 243 p.

6. Gilles T., Phelps K., Clarkson J. P., Kennedy R. Development of MILIONCAST, an improved model for predicting downy mildew sporulation on onions // Plant Disease. – 2004, vol. 88 (7), p. 695–702

7. Goncalves P. A. de S., Sousa E., Silva C. R., Boff P. Incidence of downy mildew in onion growing under mineral and organic fertilization // Horticulture Brasileira. – 2004, vol. 22 (3), p. 538–542

8. Hoffmann M. P., Petzoldt C. H., Frodsham A. C. Integrated Pest Management for Onions. New York State IPM Program Publication. – 1996, No. 119. – 78 p.

9. Hoppe BioEco. – 2004. http://www.aametica.com/Kem-Kol_results_Fruit_Veges.pdf

10. Jesperson G. D., Sutton J. C. Evaluation of a forecaster for downy mildew of onion (*Allium cepa* L.) // Crop Protection. – 1987, vol. 6, p. 95–103

11. Juhl O. Bayer: Recommendation of the best control strategy today and in five years // NJF Report of NJF Seminar 388 Integrated control of Potato Late Blight in the Nordic and Baltic Countries Helsingør, Denmark, 29 November – 1 December. – 2006, vol. 2, No. 9. – 35 p.

12. Krauthausen H. J., Richter E., Hagner S., Hommes M. Epidemiology and control (based on thresholds) of leaf diseases (*Peronospora destructor, Botrytis* spp.) and thrips (*Thrips tabaci*) in onion // Acta Horticulturae. – 2001, vol. 25, p. 137–140

13. Lorbeer J., Andaloro J. Diseases of Onions. Downy Mildew. – Nyaes, Geneva, NY, 1984. http://www.nysaes.cornell.edu/ent/hortcrops/english/dmildew.html

14. Palti J. Epidemiology, prediction and control of onion downy mildew caused by *Peronospora destructor* // Phytoparasitica. – 1989, vol. 17, p. 31–48

15. Pesticide Fact Sheet. United States Environmental Protection Agency. Office of Prevention, Pesticide and Toxic Substance (7501C). – 2007, December 19. – 44 p.

16. Robak J., Adamicki F. The effect of pre-harvest treatment with fungicide on the storage potential of root vegetables // Vegetable crops research bulletin. – 2007, vol. 67, p. 187–196

17. Schwartz H. F., Mohan S. K. Compendium of Onion and Garlic Diseases. American Phytopathological Society, St. Paul, MN. – 1995. – 70 p.

18. Sodo ir daržo augalų apsaugos technologijos, 2007–2008 m. / sudaryt. L. Raudonis. – Lietuvos sodininkystės ir daržininkystės institutas, Babtai, 2007. – 136 p.

19. UC IPM Pest Management Guidelines: Onion/Garlic, University of California. – 2002. http://axp.ipm.ucdavis.edu/PMG/selectnewpest.onion-andgarlic

20. USDA, Crop Profile for Onion′ 2003 http://pestdaa.ncsu.edu/cropprofiles/docs/-txonions.html

21. De Visser C. L. M. Development of a downy mildew advisory model based on downcast // European Journal of Plant Pathology. – 1998, vol. 104, p. 933–943

22. Wright P. J., Chynoweth R. W., Beresford R. M., Henshall W. R. Comparison of strategies for timing protective and curative fungicides for control of onion downy mildew (*Peronospora destructor*) in New Zealand. Proceeding of BCPC conference Pests and Diseases′ 2002. – 2002, p. 207–212

23. Žemės ūkio augalų kenkėjai, ligos ir jų apskaita: mokslinis metodinis leidinys / sudaryt. J. Šurkus, I. Gaurilčikienė. – Akademija, 2002. – 345 p.